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**APPLICATION NUMBER: 60/537,847**

**FILING DATE: *January 21, 2004***

**RELATED PCT APPLICATION NUMBER: *PCT/US05/01856***



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<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (280 characters max)					
DATA STORAGE SYSTEM USING PRE-EMBOSSSED LINEAR OPTICAL MEDIA					
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ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification		Number of Pages		<input type="checkbox"/> CD(s), Number	<input type="text"/>
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Respectfully submitted,

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Date

1-21-04

REGISTRATION NO.

26,418

(if appropriate)

Docket Number:

59380-016

(MCMK-3A-PR)

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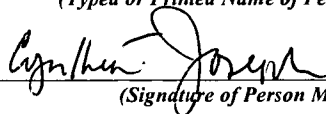
Group Art Unit

Invention: **DATA STORAGE SYSTEM USING PRE-EMBOSSSED LINEAR OPTICAL MEDIA**

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**Title:** Data Storage System Using Pre-Embossed Linear Optical Media

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**Internal Docket Number:** MC003

## BACKGROUND

In the field of optical and magneto-optical information storage systems, it has long been recognized that incorporating physical features into the surface of the storage element (disc, card, etc., hereafter referred to as "media" or "medium") provides a very effective and efficient means by which precise positioning, tracking, error correcting, focusing and other such information can be relayed to the hardware/control system (hereafter referred to as the drive or transport) by means of interaction with light from an optical pickup device ("optical head"). These surface features typically include pits, lands, grooves, and the like. For the majority of optical disc systems, such features are incorporated into the disc substrate at the time of manufacture, and this process is generally referred to as "preformatting". In the case of CD, DVD, MO (magneto-optical), and such discs, preformatting is accomplished by means of a molding process, whereby a molten polymer substrate material is contacted against a tool whose surface contains the mirror-image of the surface relief structure that is to be imparted to the disc surface (US4428069, etc.). After sufficient cooling has occurred, the disc is removed from the molding machine, after which various layers are applied, including reflective layers, recordable layers, protective layers and the like.



A durable tool, often referred to as a "stamper", is used to impart the pattern into the substrate surface and is typically made from a master pattern by an electroforming or electroless plating process. The master pattern, in turn, is made on a laser beam recorder, a device in which a photoresist-coated substrate is rotated on a lathe or spindle and exposed to a modulated laserbeam. Chemical development of the exposed pattern results in a surface relief pattern that will ultimately be replicated into the optical disc substrate, as described above.

The performance and tolerance requirements of the laser beam recorder systems that create the master patterns are very high, and therefore the process requires very expensive hardware and optical components and must be housed in a clean-room environment. The molding process used to make the polymer substrates must also mechanically reproduce the master pattern with very high precision.

The processes described above predominate the optical disc manufacturing industry and are designed to enable very low-cost media and hardware. This is achieved by placing the requirements for precision and accuracy in the mastering step, which need be done relatively infrequently, and utilizing precision batch molding processes to make replicas rapidly and inexpensively with nearly the same level of precision and accuracy as the original master pattern. This approach has enabled the production of low cost discs in high volumes, and for this reason, the process of preformatting of optical disc media has completely replaced early variants in which formatting was incorporated either after the disc was manufactured or "in the field".

The formatting of optical discs after manufacture is slow and costly compared to preformatting by molding. Furthermore, the accuracy, precision, the resolution that can be achieved in a laser beam recorder mastering facility is far greater than can be achieved by formatting in the disc drive, since the relatively inexpensive drives used by industrial an/or consumer optical disc systems do not have the same level of precision. The higher level of precision achievable by a laser beam recorder system also means that much smaller surface features can be incorporated into the inexpensive molded discs than can be created by industrial/consumer drives. Smaller features (pits and tracks, etc.) mean that more information can be stored in a given area, thus preformatted discs can have a much higher areal density than non-preformatted discs. It is commonly recognized that the low cost and high capacity of today's optical discs would not be possible without preformatting.

It is useful to compare the characteristics of the aforementioned optical disc systems to the other common form of removable information storage, magnetic tape. Magnetic tape recording systems utilize tape media that typically ranges from 4 mm to 35 mm in width and from tens of meters to hundreds of meters in length and is available in a number of spooling configurations, including open reel, single hub cartridge and dual





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spool cassette. Magnetic tape characteristically provides a very large amount of surface area for storing information. By way of comparison, the tape in a typical 120 min VHS tape cartridge has roughly 250 times more usable surface area than a CD.

In addition to their advantages, both common storage means, optical disc and magnetic tape, also suffer from a number of limitations. Disc-based systems, although characteristically having a significantly higher areal density (i.e., density of information per unit area) than magnetic tape, are limited by the total available surface area. A number of variations of the basic optical disc exist or have been proposed for overcoming this limitation, including use of multiple layers, multiple sides, gray-scale (multi-level) recording, near-field, fluorescent multi-layers, holographic, to name but a few. These variants, however, only increase the effective surface area by anywhere from a factor of 2 to 10.

Magnetic tape, while having significantly greater surface area than optical discs, suffers from lower areal density. Although very high data density has been achieved with magnetic *hard disk* systems, the storage density of magnetic tape has lagged behind hard disks by many orders of magnitude. This is due to the intrinsic difficulty in controlling the magnetic tape head-media interface as precisely as can be achieved in hard disk systems.

Magnetic tape systems additionally are susceptible to mechanical wear to both magnetic head and media because of the necessary head-media contact and the intrinsic abrasiveness of magnetic media. Magnetic tape is also characterized by a limited storage and operational lifetime resulting from degradation of the magnetic media over time. Substrate dimensional stability was discussed in a comprehensive report from the Nation Media Lab ("Data Storage Technology Assessment 2000"), which states that "PET-based tape stored at 75°C for a mere 30 min shrinks in width 0.5%. In a 200-track linear-scan fixed head drive, this level of tape width shrinkage represents one entire track pitch...In very serious cases of non-reversible width shrinkage, this phenomena could mean the end of life for the recorded tape."

It would appear useful to combine the beneficial aspects of magnetic tape (linear media with a large surface area) and optical recording (high areal density and no head-media contact), and a number of attempts to do so, generally referred to as optical tape, have been reported. To date, the only one such system has ever been commercialized (by CREO Products, Vancouver Canada, in 1991, US4567585, US5177724). The physically massive, ~\$250K CREO drive used 12-inch open reel spools of 35 mm optical tape, which held 1 Terabyte (and initially sold for \$10,000/spool). The dye-polymer-based media was developed by ICI ImageData, a subsidiary of ICI (Imperial Chemical Industries of Great Britain), and was offered under the name "digital paper" (US5382463). This system was not a commercial success and only several dozen units were ever sold. Other companies that have



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also mounted efforts to develop such drives and/or media in the past include Philips (US5784168, US5825740, US05802033, US05581534, US05734539), 3M, DOW/Southwall, Terabank, Kodak (US05321683, US05524105), and LOTS Technology (US 5120136, US06141301).

A serious drawback with the previous attempts to carry out optical or magneto-optical recording in a tape format lies in the optical head/media interaction. Virtually all of the previously mentioned systems were based on optical head technologies typically built around proprietary single or multichannel optical read/write head architectures (US5097457, US04661941, US05673245, US4884260, etc.) and unformatted tape media (US5234803, US5534385, US 5,382,463, US5,358,759, US5459019, US4904577, US4960680, US5015548, US5196294, US05465241, US5,358,759, etc.), all of which relied on complex and custom optical head designs. The developers of these optical tape system used a variety of read/write technologies, including VCSEL-based arrays (vertical cavity surface-emitting lasers), magnetically levitated spinning polygons, multiplexed high-power doubled YAG lasers with custom silicon chip channel modulators. These systems all required expensive optical heads, which drove up the system cost and development time considerably. Furthermore, those designs that used multiple beam heads were unable to deal with track pitch variations resulting from dimensional changes in the tape substrate or the loss of data rate should one or more individual elements of an optical head array fail.

There have been various proposals for dealing with some individual aspects of these problems (US 5239528, US5120136, US4633455), such as, for example an optical tape drive "including redundant optical heads to continue reading and writing data to an optical tape in the event of failure of one or more optical heads" (US06058092), but no proposed solution or previous art addresses an integrated systems (media and head) solution to solving all of these above problems.

The method described herein has been developed to extend the previous methods and attempts of the prior art as noted above, and thereby provide an optical tape system that combines the benefits of preformatted optical media used with commercially available optical heads and thus provides a practical, low-cost optical information storage system with many advantages compared to the previous art.

## DESCRIPTION

The object of this disclosure is an optical information storage system that comprises a linear optical data storage media incorporating pre-embossed information-bearing structures, a spool system for containing said media, a media transport mechanism, single or multiple optical disc heads, and related electronic and mechanical



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components and controls for read/write operations, servo and error correction circuitry, control software, etc.

The system of present disclosure enables significant improvements relative to existing storage systems in terms of areal density, storage capacity, performance and cost. The improved performance of the system described herein includes, but is not limited to, high storage capacity, improved media-drive interchange characteristics, fast data access times, high read/write rates, and archival media. Of particular significance is the benefit of a total storage capacity that is several orders of magnitude greater than any optical disc or magnetic tape system existing today.

These and other objects and features of this disclosure will be more clearly apparent from the following description when taken in conjunction with the accompanying drawings, briefly described below.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The following illustrations depict embodiments of the invention and are to be understood as not limiting in any way.

Fig. 1 shows a schematic view of head-media area of the present system, showing one embodiment of preformatted tape and multiple optical heads.

Fig. 2 shows a section of preformatted optical tape and optical heads.

Fig. 3 shows a general block diagram of the storage system of this disclosure.

### **DETAILED DESCRIPTION**

The following description refers to several possible embodiments of the disclosure and it is understood that the variations of the invention and methods described herein may be envisioned by one skilled in the art, and such variations and improvements are intended to fall within the scope of the disclosure and therefore the disclosure and methods are not limited to the following embodiments.

Now referring to Fig. 1, a sketch of one embodiment of the formatted linear substrate and head array at normal incidence is given (not to scale). The tape 1 is transported by a transport mechanism (not shown) which allows the substrate to move bi-directionally, as indicated. An optical head array 2, consisting of independent individual optical head pickup units 3, such as those typically used in DVD drives and the like, is positioned over the tape, which in turn is supported by an air-bearing or the like backing plate 4, which supports and stabilizes the lateral and out-of-plane motion of the tape 1. The lateral movement of the head assembly 2 is controlled by

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actuator 5. Focus and tracking is independently provided by each head pickup unit and related control electronics and circuitry. A sketch of the tape substrate with preformat structure and user data is illustrated in magnification 6. In this embodiment, the preformat structure is very similar to the optical disc preformat structure for which the particular optical pickup units were originally designed. It may be appreciated that, generally speaking, the pickup unit does not recognize the pattern it tracks as not being circular, since the radius of curvature of the disc track is very large compared to the width of the track, so for all intents and purposes the head "sees" linear tracks. Thus the optical disc head can be used with a "linearized version" of the disc with only some modifications. Such modifications may include the use of an optical compensator (e.g., a piece of glass or plastic) to correct the optical beam path for the "missing" disc substrate (typically 0.6 mm thick polycarbonate for DVDs), which can be bonded to the lens or interposed between the beam and substrate, for example.

A perspective sketch of another embodiment of the formatted tape with multiple heads is given in Fig. 2 (not to scale). Reading and writing is accomplished by the beams 12 from a multiplicity of optical pickup units by interaction with the surface of substrate 10, which includes an embossed format 15, in the form of a wobble land and groove structure 13 as but only one possible format. Various coatings over this structure may include layers 14 with reflective, dye polymer, WORM, erasable, protection or the like functionality.

A simplified general block diagram of one embodiment of an overall system of this disclosure is given in Fig 3. Preformatted optical tape 33 is transported bi-directionally over tape backing support 31 by the synchronized action of spools 30 and 31, whose motors (not shown) are controlled by controller unit 21. An array of independent optical heads 32 (four shown for simplicity in this example) reads from and writes to individual tracks as controlled by the multiple optical head controller block 22. Each individual optical pickup unit has a servo focus actuator 26 and tracking servo actuator 27 (typically incorporated into the head unit). System input/output is provided through interface block 25, which may utilize any of a number of high-speed standard interface protocols, such as fiber-channel, SCSI, firewire, etc.. The system controller 28 provides the user interface as well as overall system task management. Other functions, such as compression/decompression (24), error correction (23), etc. are handled by the respective processing unit. It is clear from this example that any number of hardware configurations is possible in order to create a system based on the combination of optical pickup and preformatted linear information medium.

The preformatted linear substrate can include format structures and features readable by DVD-type optical head(s), such as DVD-RW, DVD-R, DVD+RW, DVD+R, DVD-RAM as well as other format types. Such optical heads may include modifications to accommodate adjustments necessary for conversion from rotational

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to a linear format and for changes in optical path length cause by, for example, differences in the overcoat or cover sheet thickness overlaying the optically sensitive surface as compared to the standard optical disc media, as previously mentioned. The preformatted structures can also can include formats such as are characteristic of CD, magneto-optical disc, sampled servo and similar discs. The format pattern can include any of a number of general format configurations, including continuous groove, land and groove, sampled servo, wobble groove, distributed digital servo (US5452285), or the like. Format features typically include track structures, header information, servo and error correction information, and may also include pre-recorded digital and/or analog information, etc.

The layer(s) that are applied to the formatted tape may include one or more of the following functionalities: write-once (WORM), erasable, PROM (read-only and recordable combined), or read-only (ROM). The recordable and/or erasable layers can be based on phase change (US4981772, US5077181), dye-polymer (US 5382463), or any such layer or layers that are sensitive to the radiation of the appropriate optical head. The layers for ROM functionality can be comprised of aluminum or gold or other materials of appropriate reflectivity.

In other embodiments of the system of this disclosure, the optical media and appropriate optical head/drive components may incorporate other recording, detection, and information encoding schemes as are known to the art, including but not limited to grayscale (multi-level), nearfield, fluorescent, volumetric, holographic, or any other such means (e.g., *ISOM/ODS Conference on Optical Data Storage*, July 2002, HI).

Another embodiment of the recorder system utilizes either open reels, cartridges or cassettes having a single hub, or dual hubs, among others, to store and transport the optical tape media.

Another embodiment of the recorder system utilizes CD head(s) and/or DVD heads(s) or a combination of both, with the appropriate substrate preformat structure.

Another embodiment includes a drive system with read-only optical heads, which would be advantageous for readout of permanent (ROM) data, or for applications requiring playback only functionality (such as content distribution, entertainment, security, etc.), where for example the ability to write to the medium may be undesirable.

In another embodiment, an optical pickup unit (or units) having multiple beams from a single head may be employed (for example, by Zen Research, Inc., 20400 Stevens Creek Blvd, Suite 800, Cupertino CA), where such a multi-beam head may be used to increase the data rate, or for redundancy, etc.



Another embodiment of the system of this disclosure utilizes a combination of ROM and recordable functionality, which may, for example, include pre-recorded information as well as user-recordable areas, for incorporation of software, security codes, unlockable content (MP3 and video content), etc. One such example includes an array of low-power ROM heads with one or more higher-power record/erase heads for recording user data or for applying tape security serialization, etc.



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DRAWINGS

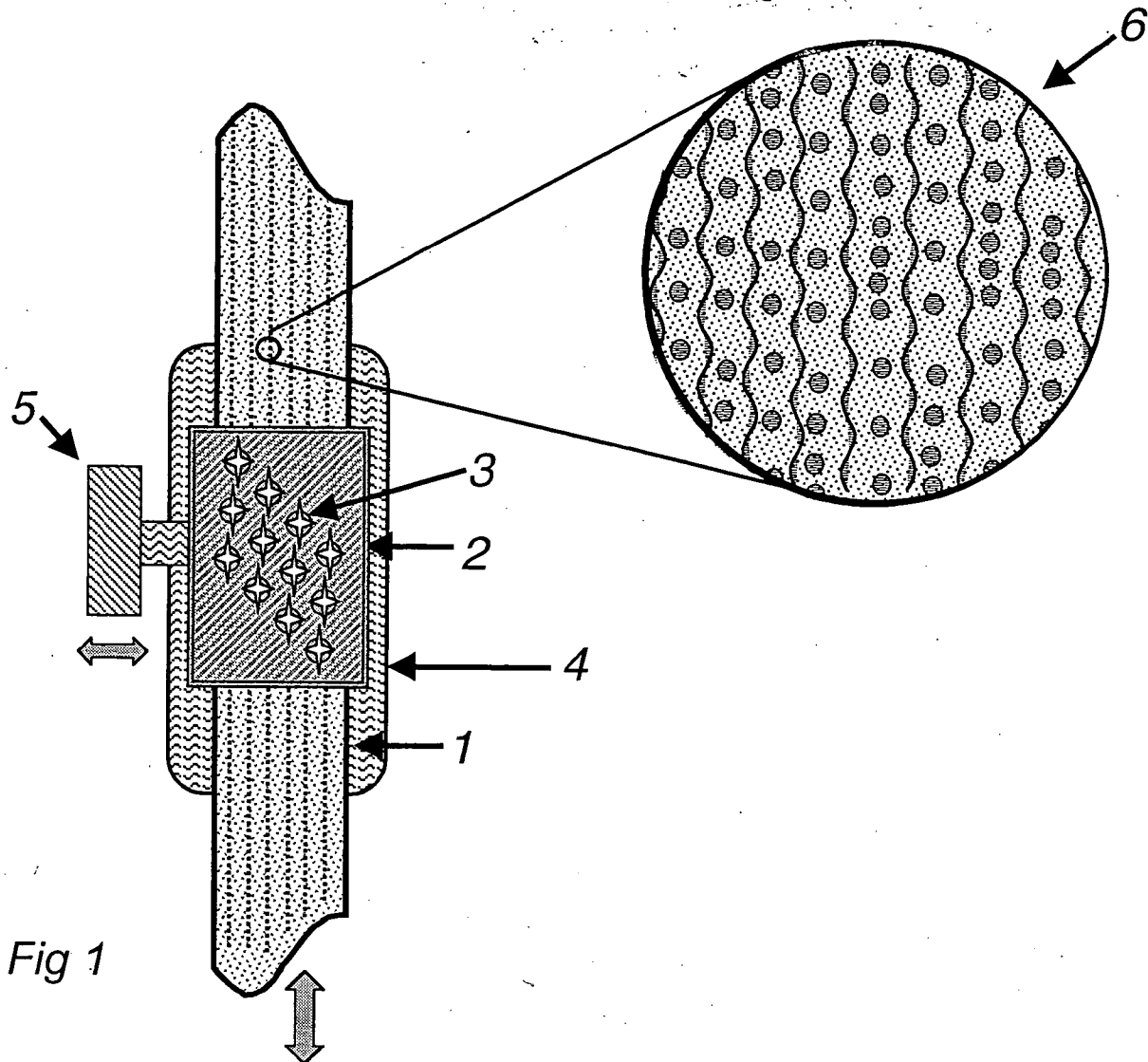


Fig 1



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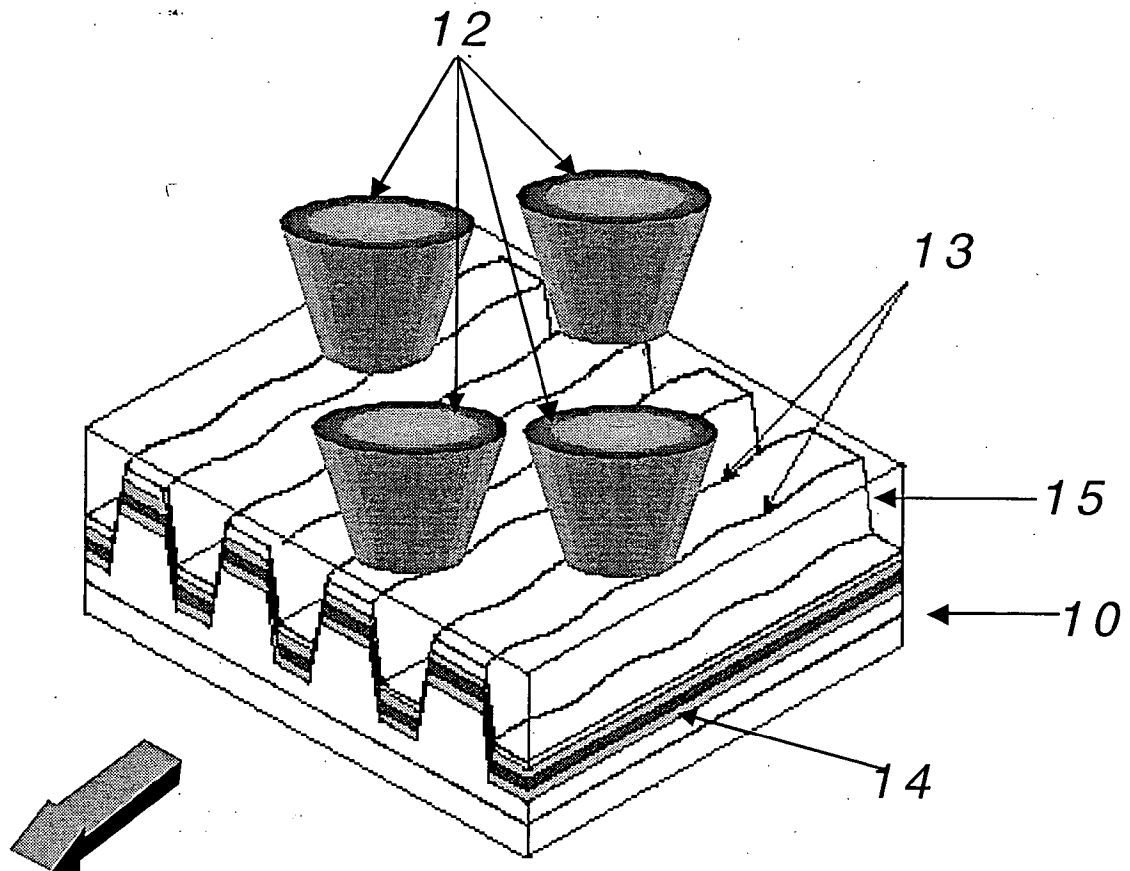


Fig 2



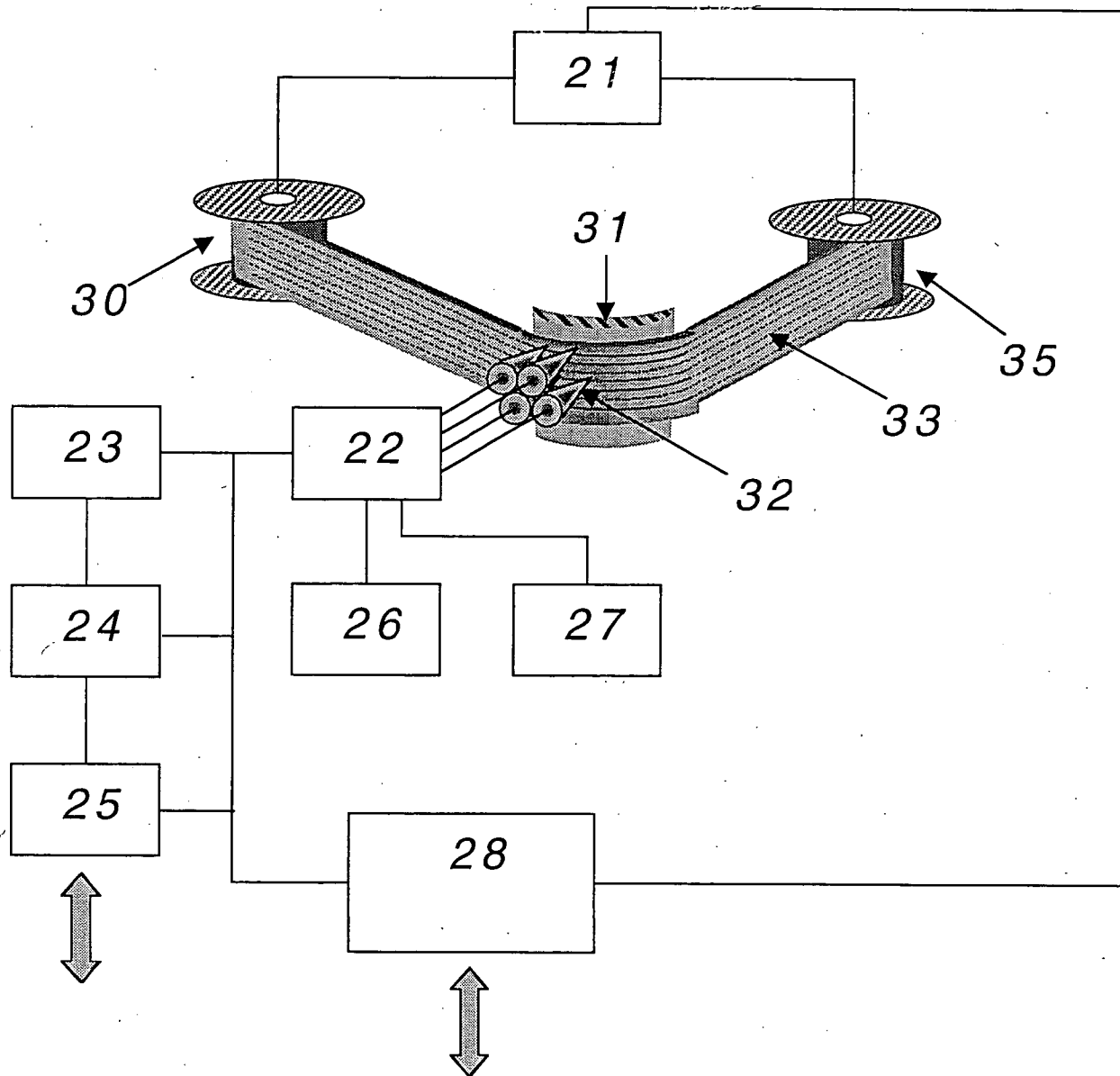


Fig 3